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Addendum

Contribution by the scientific and technological community**

Overview of recent scientific and technological developments in the fields of energy for sustainable development, air pollution/atmosphere and climate change

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** The views and opinions expressed do not necessarily represent those of the United Nations.



I. Introduction

1. The present paper, prepared by the scientific and technological community, provides an overview of recent scientific and technological developments in the fields of energy for sustainable development, air pollution/atmosphere and climate change, three of the four themes of the cluster for the fourteenth and fifteenth sessions of the Commission on Sustainable Development. Following from Agenda 21 and the Johannesburg Plan of Implementation, the sections dealing with energy, climate change and air pollution call for numerous actions focused on science and technology. This paper presents a discussion of the progress that has been made and the obstacles that still exist in implementing such actions.

2. While not discussed in depth in this paper, the Commission's theme of industrial development is recognized as a central component of essentially all sustainable development efforts, and is closely linked to the themes of energy, climate change and atmosphere. Increased efforts must be made to ensure that future industrial development is based on environmentally sustainable and economically appropriate production systems. Scientific research and technological innovation will continue to be an essential foundation for such developments.

3. As with all major sustainable development challenges, the issues of energy for sustainable development, industrial development air pollution/atmosphere and climate change must be addressed in a way that integrates the three pillars of social development, environmental protection, and economic development. In order to help decision makers define and implement these integrated approaches, the science and technology community must continue striving to become more policy-relevant, participatory and capable of addressing issues at geographical scales ranging from local to global. There is also a strong need for more integrative, interdisciplinary approaches, which will require continuing efforts to overcome persistent barriers that exist among the natural, social, engineering and health science domains.

4. The ever-increasing global demand for energy and industrial goods and services represents a daunting challenge. Basic energy services and industrial goods are urgently needed by billions of impoverished people around the world, as a necessary foundation for achieving socio-economic development. However, meeting the basic needs and the social and economic aspirations of society has traditionally required a heavy dependence upon highly polluting energy and industrial technologies, primarily through the burning of fossil fuels. This has led to dramatic changes in the composition of the Earth's atmosphere, affecting the very air we breathe and the climate that shapes the life of every human being on the planet. Whether the impacts of these changes are immediate (urban air pollution) or more slowly evolving (climate change), they affect the well-being of people in all nations and all sectors of society. The different themes for the fourteenth and fifteenth sessions of the Commission — energy, industrial development, air pollution/atmosphere and climate change — are thus part of a complex, evolving system that must be understood and addressed in an integrated fashion.

II. Energy for sustainable development

5. There is an urgent need to transform global energy systems towards sustainable pathways as current approaches are causing serious harm to human

health and to the Earth's climate and ecological systems on which all life depends, and because access to clean, reliable energy services is a vital prerequisite for alleviating poverty. At the 2002 World Summit on Sustainable Development, States Members of the United Nations agreed to improve access to "reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources". While in some parts of the world there has been notable progress towards this goal, a great deal more effort is needed, both to enhance the implementation of existing clean energy technologies and to spur further scientific understanding and technological development. Meeting the world's rapidly growing energy demands in a sustainable manner will require drastically increasing the efficiency with which energy is produced, delivered and used, and will require utilizing a diverse mix of energy sources and technologies.

A. Energy conservation and efficiency

6. Enhancing energy conservation and efficiency are key for decoupling economic growth from increased energy use, and thus for driving sustainable development worldwide. The World Energy Council estimates that nearly two thirds of all primary energy is lost before it is converted to useful energy. There is a clear need to continue making advances in areas such as: the efficiency of various energy conversion systems (burners, turbines and motors, for example); low-energy designs for electrical appliances and for heating, cooling and lighting of buildings; the dematerialization and recycling of energy-intensive material; and designing land-use and transportation systems that minimize demand for personal vehicle travel.

B. Fossil fuels

7. About 80 per cent of world primary energy is supplied from fossil fuels, a finite resource. The exact time frame over which this resource base will be depleted varies among different forms of reserves (that is, oil, coal and natural gas) and is a function of highly uncertain estimates of actual geological reserves, costs and feasibility of new extraction techniques, and future geopolitical dynamics and energy demand. Regardless, fossil fuels will remain an important part of the global energy mix for the foreseeable future, and it is thus critical that fossil energy technologies continue to evolve towards cleaner, more efficient and less carbon-intensive systems. A number of current technological developments offer promising steps in the right direction (for example, cogeneration of heat and power based on gas turbines and combined cycles; emerging microturbine and fuel cell technologies; and coal gasification to make "syngas"). In the longer term, it is hoped that carbon capture and sequestration will lead to zero-emissions fossil fuel energy systems.

C. Nuclear energy

8. Projections of the future contributions of nuclear energy are highly uncertain, due to the concerns that exist about safety, radioactive waste management, potential proliferation of nuclear weapons and vulnerability to terrorists. It is important, however, to continue developing waste disposal strategies and reactor designs that address these concerns, because nuclear technologies offer a means to provide

energy without greenhouse gas emissions, and because a growing number of countries appear strongly committed to pursuing nuclear energy options. In the longer term, some scientists view nuclear fusion as a potentially inexhaustible and emission-free means to meet the world's energy needs. The "ITER" international experimental reactor is considered to be the next major step in fusion research. The time frame for carrying out the ITER experiments, developing a prototype fusion power plant and commercial power plants is at least 50 years or longer.

D. Renewables

9. A particularly urgent priority must be placed on increasing the share of modern renewable technologies in the world's energy mix. Some encouraging progress is being made in this respect. The International Action Programme from the 2004 International Conference for Renewable Energies (Bonn, Germany) contains ambitious national targets for the expansion of renewable energy in more than 20 countries, including many initiatives for increased cooperation with developing countries. However, while the absolute amount of worldwide renewable energy use has been rising significantly, the overall share of renewables in the world's total primary energy supply has increased only marginally over the past three decades. Scenarios produced by entities such as the International Energy Agency, the World Energy Council and the Intergovernmental Panel on Climate Change (IPCC) all suggest that renewable energy sources could provide a much greater share of global primary energy demand in the coming decades if the appropriate investment and incentive structures are put into place.

10. Renewable energy systems encompass a broad, diverse array of technologies, including, solar photovoltaics, solar thermal power plants and heating/cooling systems and wind, hydro, geothermal, biomass and marine/tidal power systems. The current status of these different technologies varies considerably. Some technologies are already mature and economically competitive, while others need only minor additional development steps to become ready for the market. Certain technologies are still too expensive and may require a few decades of continued research and development before they can make large contributions on a global scale. In some cases, the "technical potential" of particular energy technologies may be much greater than the actual "sustainable potential". For instance, the large-scale use of biomass energy requires consideration of the competing land-use needs (i.e., for fuel crops versus agricultural crops) and the further expansion of large hydro projects may be limited by unacceptable ecological and social impacts. On the other hand, some renewable energy technologies, such as solar photovoltaics, appear to have virtually unlimited sustainable potential, and should be vigorously pursued.

E. Transportation

11. The transportation sector plays a crucial role in all of the focal themes of the fourteenth and fifteenth sessions of the Commission, as it accounts for a large proportion of worldwide energy demand, is a major source of air pollution and greenhouse gas emissions and is an important element of effective industrial development. The challenge is to enable freedom of mobility while reducing the consumption of fossil fuels. This requires making transport technologies more clean and efficient, and reducing the demand for personal motorized vehicle transport.

12. Transportation technologies are progressing on many fronts towards lower emissions of air pollutants and greenhouse gases, including, for instance: cars powered by electricity, hybrid electric engines and fuel cells; buses and commercial vehicles powered by compressed natural gas; the use of alternative fuels derived from various biomass sources; and continued improvements in the fuel efficiency and emissions of standard gasoline and diesel-powered vehicles. These various technological innovations are all gaining commercial success at differing rates. Their continued market penetration needs to be encouraged through appropriate economic incentive programmes and ongoing research, development, and deployment efforts.

13. Even with the aggressive implementation of cleaner vehicle technologies, there remains a strong motivation to reduce demand for personal vehicle transport, because crippling traffic congestion is a serious impediment to economic growth, quality of life and personal safety in countless places around the world. A growing number of communities are implementing effective public transportation systems although at present discouraging trends still dominate. Public transport options remain inadequate, and demand for private vehicles continues to grow dramatically, in industrialized and developing countries alike. This challenge must be addressed on several fronts, such as subsidizing mass transit development and use, encouraging "smart growth" urban development patterns and enacting public communication and incentive programmes to influence personal transport choices.

F. The role of science and technology

14. Although energy technologies are rapidly developing, it is widely acknowledged that existing solutions are not yet sufficient to meet the world's growing energy needs in a sustainable manner. Much more work will be needed for a new generation of clean technologies for heat, fuels and electricity to reach the mainstream market. These advancements must be supported with great urgency because it will take decades to realize the necessary technological innovations, to develop related markets for new technologies and to expand related production capabilities.

15. Advancing cost effectiveness and market penetration of sustainable energy systems will require technical research aimed at improved energy conversion techniques, supply structures and end-user technologies, as well as non-technical research into a wide array of related social, political and economic issues. Strategies for enabling widespread diffusion of advanced energy technologies need to encompass the whole "innovation chain", from basic research to early deployment and development of niche markets. There is a need to expand and deepen the community of scientists and engineers who work on energy issues, for instance within the disciplines of physics, chemistry, biotechnology and the social and economic sciences.

16. Given the highly complex nature and rapid evolution of energy research and development, it is important that decision makers at all levels have access to the most recent and accurate scientific and technological information. Hence there is an ongoing need for review and assessment reports, such as those produced by the World Energy Council, the International Energy Agency and IPCC. In addition, a report on research and development into energy technologies was recently produced

by the International Union of Pure and Applied Physics, and a major new assessment effort on "Transitions to sustainable energy" is currently being carried out by the InterAcademy Council.

Examples of important energy research and development topics

Photovoltaics. Achieving cost reductions for crystalline silicon and thin-film solar cells.

Wind. Developing multimegawatt turbines and robust systems for offshore applications.

Biomass. Increasing the efficiency and versatility of combustion and gasification systems. Developing commercially feasible methods for production of ethanol from cellulosic materials.

Hydrogen. Advancing technologies for hydrogen storage, and hydrogen production from renewable energy sources.

Carbon sequestration. Continuing pilot studies of the technical feasibility and ecological impacts of carbon sequestration. Advancing techniques for carbon dioxide separation and capture from waste streams.

Cross-cutting. Integrating decentralized, intermittent energy sources into electricity grid structures. Advancing systems for cogeneration of heat and power. Understanding the factors that motivate energy conservation efforts at the individual and community levels. Identifying novel financing mechanisms to overcome the economic barriers to market penetration of new energy technologies.

G. Obstacles to accelerated progress

17. Some key barriers to the achievement of sustainable energy goals include:

- *Need for appropriate economic incentives.* Economic incentive systems need to be directed towards encouraging the implementation of clean energy technologies. This requires, inter alia, including the costs of externalities such as environmental degradation in energy pricing and using subsidies to bring down the initial costs of new technologies in order to make them more competitive. As market shares increase, steady progress in lowering costs can be expected to continue through economies of scale. The historical learning curves for many renewable technologies teach us that costs per unit power fall approximately 20 per cent every time that accumulated production doubles.
- *Need for enhanced research and development funding.* Government investment in research and development in the energy sector, particularly for renewable energy sources, has been declining since the mid-1980s, and currently only a minor share of such support is directed towards renewables. At the same time, deregulation and competitive forces in the energy industry have led to private-sector research and development investment being redirected from longer-term, basic research towards low-risk, market-oriented research. There is a clear need for stronger, more consistent public support for research and

development efforts in this field, together with a policy environment that encourages private-sector investment in the desired direction.

- *Need for capacity-building.* Although a few developing countries do have notable research and development programmes in the energy sector, the vast majority of research and development is carried out by a small number of industrialized nations. Many efforts to disseminate clean energy technologies within developing countries have limited or no success because the technologies introduced are poorly adapted for local needs and/or because there is insufficient local capacity to maintain the systems over the long term. This points to a need for moving beyond a traditional "technology transfer" mentality towards a greater focus on building the endogenous scientific and technical capacity of all nations and integrating these science and technology capacity-building efforts into long-term economic development programmes.
- *Need for stronger sectoral interactions.* In general, the different energy supply sectors (fossil, nuclear and various renewable sources) have little interaction and sometimes act as competing "lobbies". Energy efficiency is, likewise, rarely addressed as a cross-cutting, strategic issue. When development prospects for different energy options are viewed in isolation from each other, opportunities for effective synergies in research and development strategies are missed. For instance, related developments in hydrogen transport and storage, fuel cells, turbines, batteries, and the like are needed for numerous renewable and fossil fuel-based energy systems.
- *Need for greater international cooperation.* Lack of coordination among national research and development programmes can lead to unnecessary redundancies, missed opportunities for productive collaboration and the problem of critical research and development topics "falling through the cracks". The transformation of the global energy system is an issue of critical concern for the entire world community and the development of technological capabilities and scientific knowledge must be encouraged in an equitable, open manner among all countries. Regional initiatives and networking between centres of excellence can be particularly effective strategies for exchange of information and expertise.

18. To overcome these barriers, there is a need for stronger mechanisms of interaction among national and sectoral research and development efforts in the energy sector and for objective international bodies that can provide leadership and guidance in the development of coherent global strategies for advancing energy systems. This need is particularly great in the realm of new renewable technologies where the institutions and infrastructures for information sharing are less mature than for more traditional energy technologies. In response to this need, the International Council for Science (ICSU) is currently exploring the idea of establishing an international science panel on renewable energy.

III. Climate change

A. Progress in climate science

19. There is scientific consensus, documented in the assessment reports of IPCC, that the increase in greenhouse gases in the atmosphere due to human activities is

altering the Earth's climate, bringing about a general global warming. Human activities, in addition to natural climate variability, are producing these changes.

20. Global scientific simulation models, which have become more robust during the last decade, have significantly increased our capacity to anticipate future risks related to the impact of climate change although they still remain insufficient as regards projections for specific regional and subregional patterns of climate change and their impact.

21. Even though a long-term (50-100 years) prediction of exactly what will happen at a specific location on the planet is not yet possible, scientists do have the ability to paint a picture of how our environment is likely to evolve in response to anthropogenic climate change. Sufficiently confident projections of future climate change do exist, including:

- Depending on the emission scenarios and climate models used, the globally averaged surface temperature is projected to increase by 1.4 °C to 5.8 °C above 1990 levels by 2100. It is very likely that nearly all land areas will warm more rapidly than the global average, particularly those at northern high latitudes in the cold season. In winter, the warming for all high-latitude northern regions exceeds the global mean warming in each model by more than 40 per cent.
- For high greenhouse gas emission scenarios, global climate change is projected to raise sea level by up to 0.88 metres over the current century. This would put vast, often densely populated, coastal areas in all parts of the world in danger of permanent flooding. Archipelagoes and coral atolls would be at risk of disappearing, and the populations living there would face permanent displacement.
- Projections indicate that extreme weather events will become more common in the future. For instance, temperature extremes, such as the 2003 heat wave in Europe, are projected to become more common in the next 50 years. There is evidence that the frequency and intensity of extreme precipitation events will increase over many areas worldwide, notably over many northern hemisphere mid- to high-latitude land areas. Hurricane intensity is expected to increase as greenhouse gas concentrations in the atmosphere rise.
- In addition, projections show that the range of environmental effects goes far beyond the kinds of weather-related events described above. Examples of other effects include diminishing freshwater supply in many regions, due to extended droughts and as a result of the melting of high-altitude glaciers and the decrease in snow cover in mountain areas.
- There is evidence of increasing acidification of the oceans due to increased carbon dioxide absorption, with far-reaching consequences for the survival of coral reefs and the dynamics of organisms in the oceans that are the basis of the marine food chain. This implies serious risks for a primary source of protein needed for a growing world population.

22. Even if greenhouse gas emissions were to be stabilized at present levels, the global warming trend and sea-level rise would continue for hundreds of years, due to the atmospheric lifetime of some greenhouse gases and the long timescales on which the deep ocean adjusts to climate change. The continuing increase in

emissions will augment the intensity and duration of their impact on the environment.

23. The most recent scientific information on climate change was recently summarized in a joint statement on the global response to climate change issued by the science academies of the States members of the Group of Eight as well as of Brazil, China and India, on the occasion of the meeting of Heads of State and Government of the Group of Eight in Gleneagles, United Kingdom of Great Britain and Northern Ireland, in July 2005.

B. Relevant ongoing international scientific cooperation programmes

24. Most of the recent advances in climate science have been generated within international scientific cooperation programmes established in the 1980s and 1990s. These programmes are the World Climate Research Programme, jointly undertaken by the International Council for Science (ICSU), the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC), of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Geosphere-Biosphere Programme of ICSU and the International Human Dimensions Programme on Global Environmental Change, jointly undertaken by the International Social Science Council and ICSU. In the years to come DIVERSITAS, another international global change research programme, dealing with biodiversity, will provide data and enhanced knowledge on the links between climate change and biological diversity.

25. In addition, WMO, the United Nations Environment Programme (UNEP), IOC and ICSU established the Global Climate Observing System in 1992 to ensure that the high-quality observations and information needed to address climate-related issues are obtained and made available to all potential users. The Global Terrestrial Observing System, co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), UNESCO, UNEP, WMO and ICSU, and the Global Ocean Observing System, co-sponsored by IOC, WMO, UNEP and ICSU, have important climate-related components.

26. The World Climate Research Programme and the International Geosphere-Biosphere Programme must be seen as the main mechanisms by which the scientific community worldwide is mobilized to provide improved understanding of the climate system. Moreover, it must be much more strongly recognized that the major foundation of the natural science assessment of IPCC is the collaborative work of many scientists and countries through both of these programmes, as well as through the global environmental observing systems.

27. Some of the research undertaken through the World Climate Research Programme and the International Geosphere-Biosphere Programme has been of major immediate socio-economic benefits. For example, with the advances in forecasting the advent of the El Niño/Southern Oscillation (ENSO) weather pattern, fishermen and farmers in the Andean coastal zones and also communities in Asia and Africa usually affected by ENSO have the benefit of early warning and thus are better able to mitigate the impacts of these events.

C. Obstacles to accelerated progress

28. In its third assessment report in 2001, IPCC reported that observational networks were declining in many parts of the world and that additional and sustained climate observations would be required to improve the ability to detect, attribute and understand climate change. While some improvements to networks have been made since the third assessment report, the overall trend has not changed significantly. Following the second adequacy report on climate observations commissioned by the Conference of the Parties to the United Nations Framework Convention on Climate Change, the Implementation Plan for the Global Observing System for Climate in Support of the Convention was prepared and approved by the Conference in 2004. This Plan, available at the WMO website, identifies 131 actions needed over the next 5 to 10 years to address the critical issues related to global observing systems for climate.

29. While the Plan outlines the actions needed to make the Global Climate Observing System fully operational and efficient, it also highlights the importance of climate-related data to be provided by the Global Terrestrial Observing System and the Global Ocean Observing System. The need for strengthening observing systems for climate data was one reason for the recent establishment of the Global Earth Observation System of Systems the advent of which represents an important step forward. Sizeable resources will have to be made available by Governments and considerable work will have to be carried out in order to realize the goals set for the System and its climate components.

30. The significant remaining gaps in our knowledge on climate change, its impacts and adaptation strategies pose obstacles to improving and accelerating implementation of climate policies. The scientific communities must continue to increase our understanding of the climate and the Earth system, to refine our predictive tools and to reduce remaining uncertainties in efforts to project future climate and the impact of change, in particular at the regional level.

31. In its fourth assessment report, due for completion in 2007, IPCC will address the state of knowledge since 2001 on some of the most important unresolved issues, such as:

- Will changes in cloud cover and characteristics and in atmospheric aerosols amplify or moderate the rate of climate change?
- Will as much as about half of the anthropogenic emissions of carbon dioxide continue to be taken up by the oceans and biosphere? If ocean circulation slows (as warming might induce) or carbon dioxide fertilization of the biosphere saturates (as may happen), much more of the emitted carbon dioxide would remain in the atmosphere. The rate of warming would further accelerate and the emission cutbacks required would need to be increased if dangerous anthropogenic interference is to be avoided.
- How fast is the ocean taking up the heat trapped by the increased concentration of greenhouse gases? Lack of knowledge on ocean heat uptake limits our ability to pin down more precisely the amount of future global temperature rise in the twenty-first century due to projected emissions.
- How will global climate change alter climates at the regional level? For example, given that monsoons provide water to more than half of the global

population, any change could have a dramatic impact. How will monsoon patterns be affected?

- Will countries, in particular those in the developing world, be able to adapt their agricultural practices rapidly in response to climate changes? How will infectious and vector-borne diseases be affected in different parts of the world?

D. Action needed now by society and in science

32. There is broad consensus among scientists that the scientific understanding of the ongoing climate change is sufficient to warrant taking urgent action in order to mitigate the impact of future climate change, including both the environmental impacts and the socio-economic consequences. Not taking action now will aggravate environmental impacts and will make the socio-economic costs even higher.

33. Action is needed in order to reduce greenhouse gas emissions. It is projected that world energy demand will continue to grow rapidly in the coming decades. Meeting this demand in a sustainable manner will require drastically increasing the efficiency with which energy is produced, delivered and used. At least for the next few decades, it will also require accepting a diverse mix of energy sources and technologies, with increased attention to be given to renewable sources of energy (see sect. II above).

34. Action is needed by countries and regions to design and start implementing strategies to adapt to the consequences of climate change, particularly for the most vulnerable regions, nations and socio-economic groups. International collaboration will promote the development of best practices and the effectiveness of strategic approaches to climate change adaptation. At all levels, participation of a broad range of stakeholder groups will be essential in this undertaking.

35. The scientific community needs to continue to increase its understanding of the climate and the Earth system and to refine its predictive tools and reduce remaining uncertainties in projections of future climate and its impacts, particularly at the regional level. In this respect, important priorities during the coming years are:

(a) To enhance long-term observations of the Earth system by making the global environmental observing systems fully operational through implementation of the Global Earth Observing System of Systems;

(b) To vigorously pursue the implementation of the World Climate Research Programme and the related global environmental change research programmes, including the International Geosphere-Biosphere Programme, DIVERSITAS and the International Human Dimensions of Global Change Programme.

36. It is equally important that a new line of interdisciplinary research be initiated, involving natural, social and economic sciences, aimed at a better identification and understanding of coupled environmental and socio-economic impacts and vulnerabilities, and at increasing the knowledge-base for drawing up possible adaptation strategies to climate change. Since climate change is an ongoing process, we must become better prepared for adapting to it and for limiting its socio-economic costs in societies worldwide.

37. The Conference of Parties to the United Nations Framework Convention on Climate Change has agreed, in principle, on the development of a five-year programme of work on impacts, vulnerability and adaptation. A workshop convened by the secretariat in October 2005 in Bonn, Germany, was dedicated to defining the content of the five-year programme of work of its Subsidiary Body of Scientific and Technological Advice. Needs identified at this workshop include:

- (a) Promoting development and dissemination of impact and vulnerability assessment tools and methods;
- (b) Improving access to high-quality data and information on current and future climate variability and extreme events;
- (c) Improving availability of socio-economic information on vulnerable populations and economic sectors and on the economic impacts of climate change;
- (d) Stimulating adaptation research and technology;
- (e) Promoting international cooperation to assist vulnerable countries in enhancing their resilience and managing climate risks, giving priority to the most vulnerable countries.

38. As a result of global warming, the polar regions are a unique barometer of environmental change. In the Arctic and in regions of Antarctica, average surface temperatures have risen much more quickly than in the rest of the world in the past decades. This fact has also been confirmed by the results of the independent Arctic Climate Impact Assessment, published in 2004. Consequently, among the topics to be investigated by the upcoming International Polar Year 2007-2008, sponsored by ICSU and WMO, climate change research must be supported strongly, in addition to the development of polar components of the global environmental observing systems.

39. The scientific and technological community also calls for continued support to the highly important work of IPCC as a forum for carrying out independent scientific assessments and enabling interaction between natural and social scientists, policymakers and other stakeholders, thus strengthening participatory approaches.

40. The links between research, long-term monitoring, integrated assessments and policymaking at the global level have been considerably improved during the last 10 to 15 years, although such links are still lacking in most regions, in particular at the country level.

IV. Air pollution/atmosphere

41. One of the most profound ways in which human activity affects the natural environment is through changes in the composition and chemistry of the atmosphere. Of greatest concern are three closely intertwined issues: the occurrence of health-damaging air pollution; the build-up of heat-trapping greenhouse gases; and the depletion of the Earth's protective stratospheric ozone layer.

A. Air pollution

42. Clean air is a basic requirement for human health and welfare and an important prerequisite for sustainable economic development. Air pollution¹ results primarily from the combustion of fossil fuels in transportation and power generation, from various industrial emissions and from large-scale biomass burning in some parts of the world. Air pollution is known to be a major factor in respiratory and heart disease and a number of air pollutants are known or probable carcinogens. Though very difficult to quantify, it is estimated that millions of people die prematurely due to air pollution each year worldwide. Air pollution also adversely affects natural ecosystems, for instance, through damage to plant growth, acidification of waterways, accumulation of mercury in the food chain and eutrophication of coastal ecosystems, all leading to impacts on agriculture, fisheries, forests and a host of "ecosystems services" upon which all life depends. Much still needs to be learned about the specific details and mechanisms of air pollution exposure and impacts on both human and ecosystem health; however, current scientific understanding provides ample evidence to warrant urgent action.

43. In most developing countries air pollution is a serious problem, the result of rapid urbanization and population growth and the consequent growth in the demand for energy and automobile transportation, combined with poor environmental regulation and highly polluting vehicles and industrial production systems. In many rural areas a major health threat (particularly among women and children) is chronic exposure to indoor air pollution, resulting from the combustion of biomass and coal in rudimentary, inefficient systems for cooking and heating. In this context, relatively small investments in implementing existing pollution control technologies could have huge environmental and public-health benefits.

44. In most industrialized countries effective regulatory programmes implemented over the past few decades have led to the introduction of cleaner technology, especially in the power generation and transport sectors, which has led to a significant improvement in overall air quality. In many places, however, the gains made by tighter regulations and improved energy efficiency and pollution control technologies have been offset by the increase in traffic (vehicle-miles-travelled) and the demand for energy. The emission of fine particulates from diesel engines and power plants is seen as a significant health risk that remains inadequately addressed.

45. A matter of growing attention and concern is the long-range transport of air pollutants across national boundaries and between continents, which can raise background pollution levels over large regions of the globe and make it impossible for any one country to fully address its air quality concerns in isolation. In the 1980s and 1990s, widespread concern about acid rain pollution in North America and Europe led to extensive research and assessment efforts that greatly enhanced understanding of long-distance transport of sulphur and nitrogen oxide pollution. More recently the scientific community has been striving to develop robust techniques for documenting long-distance transport of ozone, particulates and persistent organic pollutants. The Convention on Long-range Transboundary Air Pollution and its associated protocols have been important instruments for enhancing international collaboration, and there has been significant progress in the development of integrated regional policies for air pollution assessment and control throughout Europe and North America. There is still a great need, however, for comparable types of efforts in other parts of the world, for instance across Asia and

Latin America, where there is clear evidence that regional-level atmospheric pollution is a significant and growing problem.²

B. Greenhouse gases

46. The build-up of long-lived greenhouse gases³ in the atmosphere is well documented and is well understood to result from human activities. Further details about the consequences of this profound change in global atmospheric composition and about scientific progress and obstacles in addressing such issues are covered in the section on climate change (see sect. III above).

47. The issues of air quality and climate change are closely coupled on several levels. Most notable is the fact that carbon dioxide, the major anthropogenic greenhouse gas, and many conventional air pollutants come from the same sources (burning of fossil fuels) and can thus be simultaneously addressed through mitigation of those sources. There are also some contexts, however, that can require trade-offs between efforts to reduce emissions of greenhouse gases and emissions of conventional air pollutants. Climate change and air pollution are also linked through chemical and physical processes in the atmosphere. For instance, tropospheric ozone is a powerful greenhouse gas and particulate pollutants can have strong effects on local and regional climate. In turn, climate patterns directly affect the sources, transport and deposition of air pollutants; and a major concern is that global warming will exacerbate the problem of urban air pollution in many parts of the world.

C. Stratospheric ozone

48. The actions taken to preserve the stratospheric ozone layer provide an example of remarkable success of scientific and political cooperation in addressing a major environmental threat. As a result of the successful implementation of the Montreal Protocol and its amendments, the atmospheric concentration of chlorofluorocarbons (the man-made chemicals that destroy stratospheric ozone) has generally begun to decline. However, stratospheric ozone destruction in the polar regions and the consequent rise in dangerous ultraviolet radiation is still occurring at near record levels. It is anticipated that near complete recovery of the Antarctic ozone layer will occur by approximately 2050. The future evolution of ozone in the Arctic is more difficult to estimate, due to the more complex feedback processes involved. Some key remaining needs/challenges include:

- (a) Reducing international trafficking of existing chlorofluorocarbons and ensuring a timely phase-out of methyl bromide and hydrofluorocarbons;
- (b) Further advancing scientific understanding of how climate change can affect the dynamics of stratospheric ozone loss and recovery;
- (c) Ensuring that the effective atmospheric monitoring systems put into place over the past few decades are maintained.

49. The stratospheric ozone example is often cited as a model for the effective use of scientific information in guiding policy responses to global change concerns. It must be acknowledged, however, that other global change issues pose far more complex challenges in this respect. For instance, effectively responding to climate

change requires understanding highly complex cause-and-effect relationships and feedbacks and controlling emissions from a wide array of sources and sectors that are of central importance to social and economic development.

D. The role of science and technology

50. Effective air quality management systems are developed in the context of diverse social, economic and political considerations. However, a strong scientific and technical base is indispensable as a foundation for such systems, playing a critical role in setting appropriate emission standards and ambient air quality objectives, designing and implementing effective air pollution control strategies and technologies and assessing emissions, ambient air quality, exposure patterns and impacts on human and ecosystem health.

51. *Observing systems.* Understanding atmospheric change requires an integrated system for collecting data on a wide array of parameters, including: greenhouse gases, ozone, solar radiation, precipitation chemistry, aerosols, reactive gases and meteorology. Such data is collected through: surface-based monitoring networks; aircraft- and balloon-based measurements in the lower atmosphere; and, increasingly, space-based satellite observations. The atmospheric science community has made great progress in advancing and coordinating these complex observational networks and in applying them to study air pollution transport, map and assess pollutant emissions, develop air quality forecasting systems and support international policy formulation. The WMO Global Atmosphere Watch programme recently developed a proposal for an Integrated Global Atmospheric Chemistry Observation System to ensure more accurate and comprehensive global observations of key atmospheric gases and aerosols and to make such observations accessible to users. This new initiative could become part of the Global Earth Observation System of Systems. Likewise, ecological and human health research communities continue to advance systems for monitoring air pollution impacts. Such systems are critically important for determining priorities and evaluating the effectiveness of air quality control measures. However, linking observed trends in human and ecological health with ambient air quality trends presents a major scientific challenge, given the multiple stressors to which these systems are exposed and the wide variety of systems and responses involved.

52. *Modelling tools.* There also continues to be a great deal of progress in developing advanced atmospheric modelling tools, ranging from the local to the global scale. Notable examples include the United States Environmental Protection Agency's Community Multiscale Air Quality modelling system; the Regional Air Pollution and Simulation (RAINS) and Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) models from the International Institute for Applied Systems Analysis, which allow the user to examine the costs and effectiveness of different emission control strategies, and to design emission control strategies that simultaneously meet air quality targets and limit the emissions of greenhouse gases. A wide array of ecological and biological/epidemiological models are likewise continuing to be developed for studies of air pollution impacts.

53. *International cooperation and capacity-building.* Almost all nations share similar challenges in dealing with air pollution, but the capacity to address these challenges varies tremendously. In many developing countries the current impacts of

air pollution and the future risks that may result from different development pathways must be made clear so that decision makers can determine effective policy responses. There is a need to encourage the education and training of more scientists and engineers in order to carry out basic research and observations, to implement and maintain emission control technologies and to give competent advice to policymakers and the public. The most advanced observational and modelling tools, pollution prevention and control technologies and knowledge about best practices in air quality management must be shared effectively among industrialized and developing nations. The efforts of the International Union of Pollution Prevention Associations, the International Global Atmospheric Chemistry Project, the Global Atmosphere Watch Programme and other organizations all play an important role in advancing this international cooperation.

V. Education, training and science and technology institutional capacity-building

54. Addressing the challenges of developing sustainable energy systems, mitigating and adapting to climate change, reducing atmospheric pollution and promoting a sustainable path to industrial development requires strong and focused national, regional and global science and technology systems. However, it is now clearer than ever that these challenges have thus far outstripped the capacities both of the science and technology community and of society to forge effective and comprehensive responses. Nothing less than a massive effort will be needed in order to strengthen scientific and technological capacity in all regions of the world and, in particular, in developing countries.

A. Bridging the North-South divide in scientific and technological capacity

55. The countries of the Organization for Economic Cooperation and Development (OECD) spend annually more on research and development than the economic output of the world's 61 least developed countries. Developed countries employ 12 times the per capita number of scientists and engineers in research and development than developing countries, where there is often a woefully weak institutional capacity. This gap in science and technology capacity between the developed countries and a majority of developing countries is generally still widening.

56. Developing countries must address this problem and significantly enhance investment in higher education and scientific and technological capacity. Bilateral donors and other funding mechanisms should include science and technology capacity-building among their priority areas of development cooperation and substantially increase the funds they allocate to this sector for sustainable development. Special attention should be given to the areas of energy, climate change, air pollution and industrial development. A critical mass of scientific and technical skills and infrastructure (for example laboratories, equipment and supporting institutions) is required for all countries to: develop, adapt and produce the technologies specific to their needs; introduce these technologies effectively into the market; and provide the needed maintenance on an ongoing basis. Capacity-building at the international, regional and subregional levels must also be given

increased attention as it is often the most cost-efficient way to build a critical mass of capacity.

B. Recent initiatives and ongoing programmes

57. At the end of August 2005, the world's leading international scientific, engineering and medical organizations issued a joint statement on science, technology and innovation for achieving United Nations Millennium Development Goals (www.icsu.org/9_latestnews/latest_5.html). The statement was addressed to the Heads of State and Government gathered at the 2005 World Summit at United Nations Headquarters in September 2005. The Summit participants recognized that science and technology, including information and communication technologies, are vital for the achievement of the development goals and adopted a number of commitments in this regard. Two of the commitments refer specifically to:

(a) Assisting developing countries in their efforts to promote and develop national strategies for human resources and science and technology, which are primary drivers of national capacity-building for development;

(b) Promoting and supporting greater efforts to develop renewable sources of energy, such as solar, wind and geothermal.

58. The importance of addressing science and technology capacity-building issues worldwide has been highlighted in a 2004 report from the InterAcademy Council entitled *Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology*. The report provides a blueprint of action needed to enhance the science and technology capacity of those developing countries that still lack this capacity.

59. At the January 2004 meeting of the OECD Committee for Scientific and Technological Policy at ministerial level, Ministers adopted the Declaration on International Science and Technology Cooperation for Sustainable Development, which stated that moving towards sustainable development objectives requires better ways of cooperating internationally to build capacities in science and technology, enhancing knowledge and technology transfer and creating effective networks in the developing countries. Governments, academia and businesses in both OECD member countries and developing countries have important roles to play. In order to follow up on the Declaration, an international workshop, coorganized by the Government of South Africa and OECD, took place in South Africa in November 2005. The workshop included a particular focus on identifying good practices in international science and technology cooperation in the areas of energy and climate change. It is expected that results of this workshop will be taken into consideration at the fourteenth and fifteenth meetings of the Commission on Sustainable Development.

60. In the field of science related to climate change, the SysTem for Analysis, Research and Training (START) acts as a platform to enhance the scientific capacity of developing countries to participate in global environmental change research programmes and to address issues of impacts and vulnerability and mitigation and adaptation at the national, subregional and regional levels. START is co-sponsored by the World Climate Research Programme, the International Geosphere-Biosphere Programme and the International Human Dimensions of Global Change Programme.

It seeks to establish and foster regional networks of collaborating scientists and institutions in developing countries and undertakes a wide variety of training and career development programmes. Increased financial support for START is necessary in order to enable the programme to better fulfil its tasks.

61. Detailed needs in science and technology capacity-building in the broad area of climate change and reduction of greenhouse gas emissions have also been drawn up by the Subsidiary Body for Scientific and Technical Advice of the United Nations Framework Convention on Climate Change.

62. A major instrument for enhancing education focused on energy, climate change, air pollution and atmosphere issues will be the United Nations Decade of Education for Sustainable Development 2005-2014. Within different domains of education for sustainable development (basic education, higher education, reorienting existing education programmes, developing public awareness and understanding of sustainability and specialized training) the specific themes of sustainable energy, mitigation of and adaptation to climate change, air pollution/atmosphere and industrial development should receive particularly high attention. The science and technology community, for its part, is committed to making an active and important contribution to the Decade in this respect.

VI. Conclusions

63. The present report demonstrates that science and technology are essential means for accelerating the implementation of actions agreed in the Johannesburg Plan of Implementation, aimed at addressing the problems of climate change and air pollution and at meeting the world's growing energy demands in a sustainable manner. Progress in meeting sustainable development goals in these fields will require substantive further advances in science and technology and a massive effort in order to strengthen scientific and technological capacity in all regions of the world, in particular in developing countries.

64. The science and technology community remains committed to helping identify and implement sustainable solutions to the pressing problems highlighted here. To that end, our community seeks to enhance further cooperation with Governments, business and industry and civil society, in implementing research. We are also striving to develop new platforms for ongoing dialogue with policymakers, development specialists and the wide array of other stakeholder groups that are directly involved in meeting sustainable development challenges. These dialogue efforts are aimed at providing more open, participatory mechanisms to define key needs for new scientific knowledge and technological innovation.

Notes

¹ The World Health Organization recognizes six main types of air pollutants: carbon monoxide, nitrogen dioxide, particulate matter, sulphur dioxide, tropospheric ozone and suspended particulate matter. In addition, some countries specify as air pollutants: heavy metals (such as lead and mercury), volatile organic compounds (such as benzene and formaldehyde) and a broad array of other chemical compounds classified as air toxics.

² For instance, the INDOEX field experiment (<http://www.indoex.ucsd.edu/>) led to the discovery of a massive pollution cloud extending over the Indian Ocean, South and South-East Asia and China, with serious potential impacts on marine life, agricultural productivity, and climate and monsoon hydrological cycles. This phenomenon is currently being studied further under the UNEP Asian Brown Cloud Project.

³ The anthropogenically produced greenhouse gases include: carbon dioxide (CO₂); methane (CH₄); nitrous oxide (N₂O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF₆).



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Addendum

Contribution by farmers**

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** The views and opinions expressed do not necessarily represent those of the United Nations.



Introduction

1. Agriculture and climate change issues are closely linked. Agriculture is at the heart of climate change issues. Indeed, it is one of the sectors that contributes to greenhouse effects and a sector that experiences climate change effects. At the same time, agriculture worldwide has a huge potential to provide answers with respect to mitigating and adapting to the consequences of climate change. One of the key answers for farmers with respect to climate change mitigation and adaptation lies in the development of sustainable sources of energy.
2. Farmers around the world already bear the consequences of climate change: some crops will not be resistant to the changes brought about by climate change and harvests will wane. Costs associated with climate change mitigation and adaptation already represent an added burden for farmers. However, they cannot bear this burden alone. Thus, all stakeholders need to be involved and play their part. Climate change is everybody's concern.
3. It is crucial for an activity, like agriculture, that is so dependent on climate conditions to clearly identify these changes and to find out how to tackle them.
4. The role of agriculture in combating climate change is important and must be recognized as such. This should lead to a change in the relationship the agricultural sector and community have with Governments, society and the environment. Agriculture around the world already affects the management of land, the environment and climate. It already provides sustainable produce with low food miles while protecting the environment. Agriculture is already responding positively to climate change mitigation through substitution of fossil fuels, continued energy efficiency and carbon sequestration.
5. There is no denying that agriculture currently accounts for more than 20 per cent of the human-induced greenhouse effect (including fossil fuel emissions and deforestation — mainly in tropical areas). Because of the significant role agriculture plays in emitting greenhouse gases, any reductions that can be made by farmers are important.
6. Indeed, despite the difficulties they face, farmers are doing much to adapt to climate change and also to mitigate its effects. Farmer initiatives to mitigate and adapt to climate change exist. However, their actions are not sufficiently recognized or properly documented. To preserve the livelihoods of farmers and support the growing world population, adaptation and mitigation measures are both essential responses in planning for climate change.
7. Agriculture covers approximately one third of the world's land surface and farmers are the largest group of ecosystem managers. Therefore, farmers will be an integral part of ecosystem management designed to handle the burden brought on by climate change.
8. One of the key challenges that farmers have to deal with entails the pressure to provide food for a world population that will double to reach 9 billion people by the year 2050. In rapidly developing nations, demand for energy-intense foods, like meat, is growing, increasing the total amount of fossil fuels used. The challenge for farmers is, on the one hand, to meet food demands while on the other hand to protect the environment through minimizing the use of fossil fuels and providing bioenergy, carbon sinks, etc.

I. Agricultural sources of greenhouse gases

9. Of the six greenhouse gases identified by the Kyoto protocol¹ to the United Nations Framework Convention on Climate Change², carbon dioxide and methane, both carbon compounds, are the two that contribute most to the greenhouse effect. Agricultural soils are currently a net source of atmospheric carbon dioxide. Process, transportation and distribution of agricultural goods, as well as use of farm machinery that operate based on the use of fossil fuels, contribute to the production of atmospheric carbon dioxide. Agricultural methane emissions, on the other hand, are largely generated from biological decomposition, livestock digestion, anaerobic decomposition of agricultural wastes and anaerobic activity in irrigated rice cultivation. Certain fertilizers and other agricultural chemical inputs are also known for their ability to contribute to the greenhouse effect.

10. Although the activities described above result in the emission of greenhouse gases, most are necessary and, in many cases, unavoidable. The key is for policymakers to remove barriers and provide incentives for farmers to adopt alternatives. This would facilitate farmers' efforts to minimize greenhouse gas emissions.

II. Barriers: lack of resources

11. Increased research has led to the development of more climate-friendly farming practices. Unfortunately, lack of financial resources and policy regulation make these practices difficult to implement.

A. Deteriorated resource base

12. Farmers rely on natural resources to carry out their activities. Soil erosion, waterlogging and salinity, predicted to increase with the onset of climate change, all contribute to land degradation and desertification, leading to overexploitation of the land. Greenhouse gases are released from certain fertilizers and pesticide inputs, and from the clearing and converting of non-agricultural lands.

13. Diminished biodiversity, due to habitat encroachment, fragmentation and pesticide misuse, also leads farmers to rely on greenhouse gas generating chemical inputs to increase their yields. Because decreased biodiversity results in less-resistant crops and loss of ecosystem services, pest infestations and weather variability increase agricultural stresses. Producing substantial crop yields without greenhouse gas generation from chemical inputs or intensive fossil fuel use is a challenge.

14. Pressure on water resources due to increased crop intensity brings about increased water resource competition in areas where water resources are scarce. Therefore, this situation may lead to conflicts. Unfortunately, the decreased water resource base is a reality that must be addressed in a long-term perspective. Without access to fertile land, uncontaminated water and a healthy biological ecosystem, farmers' livelihood is in danger.

B. Local knowledge generation and dissemination

15. Given the lack of detailed regional information on climate change impacts, specific predictions and adaptations are difficult to make. Modelling error and lack of specificity mean that even the most sophisticated models may not allow farmers and growers to adapt to future changes. There is obviously a lack of guidance on climate change adaptation and also a lack of capital with which to put necessary adaptations into place.

16. In particular, there is a lack of communication between researchers' and farmers' communities. In fact, researchers fail to address the full scope of the challenges faced by farmers and therefore do not bring adequate solutions that would meet the farmers' needs. Besides, farmers' needs and concerns often vary from one country to another and even from one region to another. Indeed, often research developments for increasing yields apply only for specific conditions, or require a high degree of knowledge transfer for the realization by farmers of the yield gains. Poor rural frameworks hamper the knowledge dissemination needed for farmers to benefit from research developments. These failed attempts may discourage them from adopting new methods in the future.

17. There is a lack of pro-poor farming research. Because poor farmers lack financial resources to commission research projects and lack access to research institutions, many of their needs remain unrecognized or unmet. These needs include research on farming systems that do not require purchased inputs or advanced technology but that would make efficient use of existing technologies, local knowledge and traditional practices.

C. Insufficient policy frameworks and regulation

18. At the national level, two inadequacies must be addressed. First, policy frameworks for addressing climate change impacts and adaptation measures are often incomplete; and second, government policy frameworks and regulation objectives are often inconsistent with climate change adaptation and mitigation goals.

19. Appropriate policies and regulations that are needed to create incentives and remove barriers to climate change adaptation and mitigation have not always been fully implemented. These need to be implemented so that markets can guide farmers' choices concerning farm management and energy, agricultural input and natural resource use. When these policy frameworks and regulations are only partially implemented, there is insufficient support for the full-fledged undertaking of climate-related activities, and market trends may lead farmers to make unsustainable farming choices.

20. There is often a lack of synergy between policy (such as climate change policy) goals developed under environmental ministries and policies developed under other ministries. In order for climate change policy and regulation to be effective, policy goals developed under different government structures must be harmonized.

D. Insufficient infrastructure and services

21. In many rural areas, deteriorating and outdated infrastructure has lost its resilience to climate-related extreme events such as hurricanes and droughts. Also, there is a general lack of services, hindering knowledge access. Without sufficient infrastructure, roads, storage facilities and irrigation services are susceptible to physical damage from climate-related events, and farmers become increasingly vulnerable.

22. The need to develop climate-related codes for infrastructure design and prepare for the onset of specific climate events will also require sufficient services for early warning so that farmers may make appropriate decisions concerning their crops and livestock. In developing countries, many of these required services are insufficient.

E. Financial capital and resilience

23. Climate change brings widespread weather events that affect whole communities at the same time. Traditional insurance markets and informal insurance arrangements between farmers and community members are inadequate in respect of preparing for climate change. Farmers who try to insure themselves through asset accumulation, savings and access to credit may also have trouble at the onset of a crisis, as these are often insufficient and may be easily damaged. For example, at the onset of a flood, physical assets such as property and land may be damaged, while community financial aid will be severely stretched as a result of the widespread effects.

24. Farmers living in areas where food security and resources are scarce lack financial capital. Often, they cannot afford to invest in new sustainable practices to prepare for climate change. For example, switching from traditional till agriculture to a more climate-friendly agricultural practice such as conservation agriculture may result in decreased crop yields for the first few seasons while farmers perfect their techniques. However, in the long run, the gains accruing from climate change mitigation will pay off. Extreme events, such as droughts, floods and hurricanes, will be less extreme and less frequent with successful mitigation. Unfortunately, there is often a conflict between long-term investment directed against climate change and short-term food security.

III. Farmers and agriculture as key to mitigating and adapting to climate change: farmers-driven initiatives as offering new opportunities to expedite implementation

25. In the context of economic development and a growing world population, farmers are already making efforts to mitigate climate change consequences by increasing the efficiency of their farming practices, reducing emissions and adopting carbon sequestering practices.

A. Support for climate-friendly initiatives and technologies

26. For farmers to work on combating climate change effectively, they need to stay up to date and informed on the most appropriate sustainable farming technologies and practices and have the means to adopt them. Farmers should also look beyond their own farms, and participate in efforts of the whole rural sector to mitigate climate change. For example, those engaged in commercial agriculture can choose to extend business partnerships with companies committed to sustainable operations. Those farmers who do not have the means to do so should benefit from support incentives from Governments. The role of the international community in terms of resource mobilization is also very important in this regard.

B. Support by farmers' organizations of individual farmers in adaptation and mitigation initiatives

27. Being aware of climate change as a threat to the farming sector and community, some apex farmers' organizations throughout the world already promote renewable energy policies, and support agricultural initiatives aiming at mitigating and adapting to its adverse effects. For instance, the National Farmers Union of England and Wales is anticipating likely climate changes and is helping the farming and horticulture sectors to understand, adapt to and play a full role in mitigating the effects of climate change.

C. Sustainable farm management practices and conservation agriculture to foster carbon storage

28. Farm management techniques in the context of tillage, crop management, water management and chemical inputs are already used by farmers as the means to optimize productivity while reducing greenhouse gas emissions.

29. Through conservation agriculture practices, farmers contribute to reducing emissions while combating land degradation. Conservation agriculture promises economic and environmental benefits. Leaving crop residues on the soil changes the surface characteristics. It increases rainfall efficiency, as water gets caught by and then percolates through the residues and soil. Generated run-off is less erosive and less polluting as crop residues reduce sediment transport into river waters.

30. No-till or minimum tillage agriculture is also less labour-intensive, as it reduces wear and tear on machinery and reduces fuel consumption. The lands concerned stock twice as much carbon as other lands. Well-managed forests also constitute net carbon sinks.

31. Therefore, adopting conservation agriculture contributes to changing farmlands from net carbon sources to net sinks. Besides, adoption of sustainable agriculture practices helps reduce food miles.

32. Farmers also adopt other crop management strategies to mitigate climate change impacts. These include crop rotation, increased crop diversification, and introducing integrated pest management systems.

33. Appropriate management of fertilizer and pesticide use can increase farm yields. While some chemical inputs generate greenhouse gases, some farmers choose alternatives, or specially treated inputs to reduce their emissions. They also use techniques such as: precision use and timing of fertilizer applications to meet crop needs, use of advanced control-release fertilizers and systems delivering fertilizers to plant roots through leaves. These can reduce total chemical inputs and at the same time help farmers maintain or increase yields. Other examples include use of additives in cattle feed to increase milk production or growth rates and decrease methane production per unit beef.

34. Methane emissions from agriculture are a source of greenhouse gas. Their reduction can be achieved through changing feed ingredients in livestock farming so as to improve the digestibility of forage. Farmers support innovations in feeding practices for methane reduction in ruminants.

35. *Sustainable management of forests: carbon sequestration.* Forests contain just over half of the carbon residing in terrestrial vegetation and soil. The carbon stored in the soil and litter of forest ecosystems also makes up a significant proportion of the total carbon pool. Carbon is stored in living biomass, including standing timber, branches, foliage and roots, and in dead biomass, including litter, woody debris, soil organic matter and forest products.

36. Increasing carbon accumulation in forests can be achieved by creating or enhancing carbon sinks (through afforestation, reforestation, improved silvicultural practices) or by preventing or reducing the rate of release of carbon already fixed in existing carbon sinks (through preventing deforestation; improved silvicultural practices).

37. Carbon emissions can be reduced through increasing the use of wood (which is a renewable resource), either for durable wood products or for biofuel, in place of fossil fuels. The role of forests and forestry for energy is growing. The case of a country such as Finland is telling. About 99 per cent of farms in this country use wood for heating purposes. In 2004, 68 per cent of farmhouses were heated by wood. For agricultural production, farms use light oil for tractors and other machinery and also for grain drying. Farmers are developing markets for forest residues and other wood by-products. Farmers and forest owners also produce heat and electricity which they sell to small and medium-sized enterprises in industry and the public service sector.

38. The use of wood products in place of materials that are associated with the release of large volumes of carbon dioxide could lead to significant net reductions in carbon dioxide emissions. However, forestry measures alone are not sufficient to halt the increase in atmospheric concentrations of carbon dioxide, although they can complement efforts by reducing carbon emissions. One of the primary measures to be taken to address climate change encompasses reducing the utilization of fossil fuels and combating desertification.

39. When addressing climate change through forestry measures, other aspects of sustainable forest management (economic, social and ecological) should be taken into consideration. Cross-sectoral dialogue and cooperation are needed to achieve best practices to combat climate change, as well as coordination and integration of sector policies having an impact on climate change.

D. New opportunities and challenges

40. In order to encourage farmers to use biofuels as a response to climate change, Governments must help to provide access to the necessary infrastructure and markets.
41. To reduce anticipated negative effects of climate change, preventive measures need to be developed and implemented.
42. Strategies devised to fight climate change must take into account the double role of the agricultural sector as both an emitter of carbon dioxide and a promoter of carbon sequestration.
43. There is a need to continue to expand scientific research on global climate change with a view to deepening knowledge on the impacts of climate change and also to coming up with new approaches and agricultural practices that are "climate-friendly" and, at the same time, with a view to achieving greater production efficiency and developing bioenergy sources.
44. There is also a need to develop links between research communities and farming communities to allow information to reach the latter in a farmer-friendly format. There is a vital need for better-focused farm-specific climate change information.
45. Increased funding opportunities are needed for climate change adaptation as well as mitigation measures.
46. A greater dialogue among the members of the farming community is needed to improve the documentation of their position on the issue of climate change and also in order to exchange knowledge.
47. There still is a need to raise awareness on the following:
 - (a) The important role of agriculture in combating climate change;
 - (b) The consequences of not adapting to climate change;
 - (c) Short- and long-term aspects of dealing with climate change.
48. *Involving farmers' organizations in decision-making processes through the creation of follow-up commissions on climate change.* It is of the utmost importance that climate change issues and problems be identified so as to enable the design of appropriate instruments and tools with which to mitigate their effects. The establishment is needed of a follow-up commission that would be in charge of implementing and monitoring strategies aimed at fighting climate change. In this regard, farmers and rural communities would need to be involved in this commission along with other stakeholders, including relevant public authorities and non-State actors at large.
49. It is essential to recognize the important role of farmers and growers as representing not only one of the sectors most affected by climate change but also a sector with a huge potential in the design of instruments and tools with which to address this problem. Participation of farmers is vital through representative professional organizations which must play an essential role in decision-making, design and implementation in respect of actions related to climate change strategies.

50. Many farmers believe that climate change offers them a real opportunity to develop new crops. They are ready to adapt to new conditions.

IV. Reduction of greenhouse gas emissions through renewable sources of energy, non-food production and carbon storage

51. Developing sustainable sources of energies is, without any doubt, one of the keys to mitigating climate change and its adverse effects. Concerns about global warming and production of greenhouse gases from fossil fuels are stimulating increasing interest in renewable energies.

52. Renewable energy is intimately and inextricably bound up with farmers and farming activities. Renewable energy is increasingly becoming a key issue in the international agenda. Global oil production is already peaking, yet consumption is expected to continue rising in the coming years. Moreover, fossil fuels, the largest single source of world energy, will eventually run out. It is not a question of *if* but rather of *when* this is going to happen.

53. All sources of renewable energy require large land areas within which to gather relatively large collectors in order to produce meaningful amounts of energy. Farms are generally the only places where large enough areas are available to construct large wind generators and large solar power voltaic cells and cultivate large areas of suitable biomass for energy.

54. Farmers are therefore well placed to take advantage of the growing attention to renewable energy supplies. Increased utilization of renewable energy will have a significant impact on agriculture in both the short and the long term. Agricultural sources of energy are becoming the new paradigm for the food and energy business.

55. Renewable energies include: biomass for fuel (wood and straw), biogas, biofuel (bioethanol and biodiesel), electricity cogenerated from sugar cane, solar energy, wind energy, thermal hydroelectricity, and fuel cells.

56. Bioenergy can be marketed, depending on the needs of the customer, as a source of electricity, heat or fuel.

Renewable energies from agriculture

57. *Biomass.* The increased use of biomass for energy production and heating should be fostered as one of the most effective climate protection measures.

58. The development of local sustainable energy networks based on biomass production can play an important role through locally based combined heat and power plants.

59. *Biomass as a source of energy in Germany.* Over the past three years, private investors have invested more than 3 billion euros in generating energy from wind, water, sun and biomass. By expanding the use of bioenergies, the farming and forestry sector in Germany is making an important contribution to fulfilling national climate protection obligations.

60. It is important to note that renewable energies currently account for about 9 per cent of gross electricity consumption in Germany; this translates into a cutting of carbon dioxide emissions by 50 million tons per year.

61. *Wood.* The burning of wood in private stoves represents the oldest and still the most common form of biomass use. Increasingly, wood is used in pellet heating systems (using pellets made from dried natural wood chippings). There are currently about 1,000 biomass heating stations in Germany, each with an output of over 1 megawatt (MW). Forty million solid cubic metres of wood are harvested each year from forests in Germany; some 60 million cubic metres are growing, which would make a further 20 million cubic metres available as fuel for heating. As a result, in the long term, approximately 3.5 million tons of heating oil could be replaced, hence 12 million tons of carbon dioxide emissions could be avoided.

62. *Straw and cereals.* With prices of finite fossil fuels rising and cereal prices falling to record world market levels, it is becoming economically interesting to use cereals, in addition to straw, for energy production.

63. In respect of biomass as a source of energy in the case of Kenya:

(a) Causes of depletion of energy sources. Increasing pressure on agricultural land due to a growing world population has led to encroachment on forest reserves. Poverty and unemployment have pushed people indiscriminately into activities that might provide a living, for example, the felling and selling of firewood and the production of charcoal. At the same time, replacement of the depleted trees is not forthcoming. This situation results in scarcity of fuelwood and charcoal and pushes many farmers to use elementary forms of energy sources such as cow dung and maize stoves;

(b) More sustainable energy production. In order to escape from this unsustainable situation, farmers in Kenya are making significant efforts to use available sources of energy in a more sustainable way. These efforts include:

(i) The use of improved stoves. These firewood stoves use only two to three sticks of firewood at a time, thereby reducing the consumption of firewood. Some stoves use dust or residues from processed rice, maize and other crops or from sawdust. These stoves are more economical than the traditional charcoal stoves;

(ii) Fireless cookers. These are baskets made out of reeds whose inner sides are well lined with warm and insulating materials that prevent the loss of heat from a boiling pan inside them. The pan is brought to a boil on the fire and then removed, wrapped up in a dark cotton cloth and placed inside the fireless cooker where it continues to boil without a source of fire. These cookers are also used to keep food warm, thus eliminating the need to warm food over an energy source;

(iii) Mud-coated charcoal chips. The effort to use these chips represents savings in terms of the proper use of charcoal through the utilization of what would otherwise be thrown away as waste;

(iv) Kahawa coal. These are pellets made by grinding the wastes from coffee husks and mixing them with clay and water. The pellets are then granulated and dried in the sun. As charcoal chips, these forms of energy prevent farmers' misuse of trees.

64. *Biofuels.* Liquid biofuels are renewable transport fuels made from plant materials. Biofuels come in two forms: biodiesel used as a fossil fuel diesel substitute; and bioethanol used as a fossil fuel gasoline substitute. Biodiesel which is made by processing rapeseed oil and other vegetable oils, is widely available globally, particularly in France and Germany. Bioethanol, which can be made from processing maize, sugar cane and beet, wheat, potatoes and a variety of other starch and sugar crops, is widely used in Brazil, the United States of America and parts of Europe.

65. Biofuels offer some 60 per cent carbon dioxide saving on their fossil fuel equivalents. They represent a key tool in the fight against global warming, as their production process results in fewer greenhouse gases emissions.

66. Biodiesel is already commercially available in Europe and the United States and interest in producing increased volumes of biodiesel is intense. In Brazil, bioethanol has been used as a commercial liquid fuel for many years. In countries south of the equator, specifically in African countries, fuel is relatively expensive and in some areas not available at all. These countries are generally poor and find it hard to generate enough foreign exchange to import sufficient quantities of crude oil-based liquid fuels.

67. Farmers are in favour of giving higher priority to this renewable energy production. They are willing and able to produce biofuels and have the potential to produce much more than what they are already producing.

68. Besides, it is more efficient to reward energy conservation rather than to simply penalize energy use. Some apex farmers' organizations already promote an alternative carbohydrate-based renewable energy policy. Adaptation measures should be focused on efficiency and conservation.

69. *Biofuels as a source of energy in Europe.* At the end of the past century, when heat engines appeared, people were conducting experiments with ethanol derived from beet as fuel. In 1974, prices of petroleum had risen sharply, and in 1980, Governments were fighting against air pollution generated by the transportation sector. At that time, ethanol began to be developed as a source of energy and as a "clean" fuel. Today, several countries in the European Union (EU), including France, Sweden and the Netherlands, are implementing a sugar beet fuel network. In Sweden, 200 buses and 200 vehicles are working with ethanol as fuel. The process is different from the one implemented in France: in Sweden, ethanol is used pure as fuel, whereas in France it is mixed with isobutylene to yield ethyl tertiary butyl ether which is then blended with traditional fuel.

70. In EU, oilseed plants, particularly rapeseed, are used more often than sugar beet to produce biofuel. The ester methylic, obtained from rapeseed, is used in France for diesel vehicles; it is used in Germany without mixture, and as heating fuel in France and Italy. In 1995-1996, the size of areas devoted to rapeseed growing for fuel reached 615,000 hectares, representing a large part of the 968,000 hectares devoted to non-food crops.

71. *The United Kingdom of Great Britain and Northern Ireland and the European Union (EU) biofuels directive.* The EU biofuels directive,³ adopted in 2003, is concerned with the substitution of conventional oil-derived transport fuels, diesel and petrol, by biofuels derived from agricultural crops. The primary motive of this directive is to ensure security of European-derived energy supplies and

environmental sustainability relating to climate change, Kyoto targets and the unsustainable increases in EU transport energy consumption (which currently accounts for 28 per cent of EU carbon dioxide emissions and is predicted to account for 90 per cent of the increase in these emissions to 2010⁴). To achieve its objective, the directive is accompanied by an energy tax directive,⁵ together with which it sets indicative targets for biofuel substitution and sets out a legal framework for fiscal and other national measures to promote biofuels.

72. These directives set out indicative targets for the biofuel share of all transport fuels at 2 per cent by December 2005, and 5.75 per cent by December 2010. Member States set their own targets but must report annually on progress. The Commission will evaluate progress of member States, cost-effectiveness, environmental and economic impacts, life-cycle analysis and impact on greenhouse gas emissions. The Commission can propose changes to targets, including mandatory targets, if member States cannot justify non-compliance.

73. In the United Kingdom, the latest research shows that 70 per cent of CO₂ emissions can be eliminated by utilizing current technology biofuels from crops.⁶

74. *The National Farmers' Union biofuel policy.* The National Farmers' Union (NFU) of the United Kingdom:

(a) Wishes to see a thriving domestically supplied United Kingdom biofuel industry develop;

(b) Believes the EU target of a 5.75 per cent share of renewable road transport fuel in the United Kingdom by 2010 is realistic — provided government policy and strategy proactively promote and support the industry;

(c) Acknowledges the financial support of a 20 pence per litre duty rate cut but concludes that this alone is not enough to meet United Kingdom and EU targets, nor to kick-start the United Kingdom biofuel industry;

(d) Wants a renewable transport fuel obligation (RTFO) to be put in place and also wants to see increased cooperation across government departments, involving non-governmental organizations and a firmer government commitment, in order for the United Kingdom to succeed in fulfilling EU indicative targets and a longer-term strategy beyond 2010. Following intensive government lobbying by the biofuel industry and the National Farmers' Union and through National Farmers' Union alliances with NGOs, the Government has accepted a clause in the energy bill that would give the Government the primary powers in respect of introducing a renewable transport fuel obligation.

75. The main advantages for the United Kingdom in producing liquid biofuels include the following:

(a) Immediate introduction into modern gasoline and diesel supply systems without the need for costly development or engine modification;

(b) Uptake of the unique opportunities of Common Agricultural Policy (CAP) reform and rapidly emerging EU biofuel markets;

(c) Maintenance of Great Britain's biodiversity through encouraging mixed cropping and continued active agricultural land management. Through support of a domestically fed biofuel industry, a base will be placed in the cereal and oilseed

market and new markets found for the restructured sugar beet industry, without which marginal land is predicted to become a monoculture of grass;

(d) The fact that biofuels are biodegradable, and are ideal for inland waterways and other environmentally sensitive areas. Bioethanol has been shown to reduce nitrogen oxide emissions by 50 per cent;

(e) Utilization of current low-value exportable surpluses in cereals and oilseed rape, ensuring minimal-land use change required to supply a 2 per cent biofuel target.

76. *Liquid bioenergy sources in Germany.* In 2003, German farmers planted about 460,000 hectares of oilseed rape to produce about 650,000 tons of biodiesel. Depending on the requirements of crop rotation and location, the area for the cultivation of oilseed rape for biodiesel could be expanded to 1 million hectares, covering approximately 5 per cent of German diesel demand in the medium term. The production of bioethanol, the raw materials for which are cereals and sugar beet, is expanding. With an estimated total capacity at three locations of 500,000 tons, this is a very promising beginning to the opening up of a new sales channel in the area of motor vehicle fuel.

77. The oilseed crop comprises three essential parts. The leaves may be utilized as green manure or forage. The straw may be burned on the farm to provide heat or electricity. The seed is pressed to extract its oil content and the remaining cake can be either used as high-protein-content cattle fodder or burned as an energy source for the production of electricity.

78. *Importance of biodiesel in South Africa.* South Africa is at present highly dependent on imported crude oil for the production of transport fuels and more specifically diesel (71 per cent of South African diesel demand is supplied from crude oil). In 2000, the Government asked the Department of Science to produce a study on how to reduce South Africa's dependency on crude oil products. Biofuels were recommended as one of the technology options that required further investigation.

79. The process in question involves the reaction of vegetable oils with an alcohol (ethanol or methanol) in the presence of a catalyst to produce the diesel (with glycerol as the by-product). Depending on the oil used, the filtration step leaves a protein-rich filter cake, which could be used as animal feed or for human consumption. It is worth noting that South Africa imports oilcake and glycerol to a value of over 1 billion rand per annum. Oil sources include soya, sunflower, jatropha, groundnut, cotton, canola and a number of others.

80. Biodiesel production has many benefits:

- (a) Environmentally friendly;
- (b) Limited energy resources;
- (c) Domestic economic considerations (leverage farming activities, increased domestic protein production);
- (d) Reduced oil import dependency;
- (e) Excellent lubricant characteristics.

81. However, it entails some risks as well, involving:

- (a) Domestic availability of soya beans;
- (b) No long-term availability of feedstock;
- (c) Climatic conditions;
- (d) Unpredictability of forecasting;
- (e) Price volatility;
- (f) Exchange rate;
- (g) Unrelated price benchmarking.

82. One problem stemmed from the contention that there could be no justification for producing renewable fuels from food sources while people were starving. However, a study by the South African Government concluded that by producing fuels from soybeans on a commercial basis, the country would be able to produce significantly more food in the form of protein-rich soy oilcake and maize at the same time. The South African study proved that the production of biofuels would not reduce food production in African countries, but rather would increase it.

83. The targeted farmers do not just sell seed, as is the case within the edible oils industry, but own, in a cooperative venture, the technology platform for extraction of the oil and enter into a separate agreement with the petrochemicals company that is buying the oil to have access to the oilcake and glycerol for a separate venture, in which the targeted farmers hold a significant interest.

84. The price of feedstock used in the production of biodiesel relative to petroleum prices is a key determinant in the feasibility of biodiesel. The economic feasibility of producing biodiesel in South Africa will always be determined by the ratios among the international price of crude oil, the local diesel price and the prices of oilseeds such as sunflower and soybean.

85. It is expected that South Africa will lead other African countries in the commercialization of biodiesel.

86. *Alcohol from sugar cane provides fuel in Brazil.* After 400 years of transforming sugar cane into sugar, bio-alcohol from sugar cane managed to dethrone sugar in only one decade, supported by two petroleum shocks. The last 50 years clearly demonstrate the change that began with the PROALCOOL programme in 1975-1976. Prior to that, alcohol had absorbed only 15-20 per cent of total sugar cane production. It was part of the federal government policy to use alcohol as an instrument with which to absorb the constant surplus of sugar cane production. This was achieved by virtue of the splendid adaptation of the sugar cane culture in the centre-south region of Brazil; the better security offered to the producer by sugar cane; the Brazilian experiences with the utilization of fuel alcohol; and the known risks of agriculture related to climatic variations. Beginning with the PROALCOOL programme, with its incentives for the expansion of alcohol production, sugar cane production in Brazil rose very steeply in only 10 years, or within two full plantation cycles.

87. Brazil is leading the way with a high consumption level of ethanol and the great success of flexi-fuel cars. These can be run on both gasoline and alcohol in

any proportion. It is worth noting that, in May-June 2005, flexi-fuel vehicle sales in Brazil overtook sales of gasoline cars for the first time.

88. The indirect results have been:

(a) Valorization of the sugar cane agro-industry and its decentralized development in practically all States of the country, with all the favourable impacts already known;

(b) The creation of direct jobs: 1 million in rural areas in Brazil;

(c) Research aimed at achieving a better tonnage of sugar cane per planted hectare, with modern techniques of planting, cultural treatments, phytosanitary control, and use of seed cane varieties resistant to diseases and pests and with a greater production of sucrose per area planted being just some of the aspects of this research;

(d) The fertilizing characteristics, with a high content of organic matter and potassium, of the effluents from distilleries.

89. The organic matter is important in soil reclamation, mainly in the areas of the Brazilian Cerrado, and potassium is the most important element lacking in the soils, being the main component in the fertilizer formulae used in sugar cane production. The cultivation of different energy crops will in future enrich crop rotation and hence improve plant diversity. Soil protection can be maximized through the use of direct sowing methods for energy crops. Closed loop systems enable the amount of fertilizers that is used to be reduced. In addition, in the case of liquid manure undergoing digestion in a biogas facility, for example, nutrient recovery is more efficient and methane emissions and smell are considerably reduced.

90. Sugar beet and cane growers worldwide are struggling to cope with inflation of production costs and drastic decreases in real revenues. However, the increase in demand for ethanol offers an alternative output and better prices on world markets, and should help the sugar economy and encourage young people to continue family farming of beet and cane.

91. *Biogas: gaseous bioenergy sources in Germany.* There are currently about 2,000 biogas plants in Germany, the majority operated by farmers. Their total output is approximately 255 megawatts. Besides commercial fertilizers and food waste, biogas plants increasingly process energy crops such as cereals, maize (whole plants) and grass. This could potentially cover 5.5 per cent of Germany's energy needs. In order to exploit this potential to the full, the German Farmers' Association calls for the promotion of bioethanol production from sugar and/or cereals in a manner corresponding to that of biodiesel. Industry is ready to make the necessary investments.

92. *Sugar cane cogeneration of electricity: bagasse from sugar cane generates electric energy in India.* In a sugar cane-rich country like India, bagasse can play a very important role in meeting the raw material requirements of the pulp and paper industry as well as allied products like particle board. Apart from this, there is enormous potential in the Indian sugar industry for producing surplus electric energy for outside sales. India is currently producing about 270 millions tons of sugar cane annually, about 50-55 per cent of which is utilized for the manufacture of crystal sugar generating over 40 million tons of bagasse annually. The rest of the sugar cane is diverted for the production of jaggery (uncrystallized sugar), etc.; the

mill wet bagasse produced per tons of sugar cane crushed contains electrical energy to the tune of 790 kilowatt-hour units out of which only about 30-35 kilowatt-hour units are required for the production of crystal sugar. Thus, there is an enormous potential for producing surplus electric energy in a sugar plant. All the sugar factories are located in rural India. This has led to the tremendous development of rural areas. These factories become the focal point of rural development in the area of operation. They help in the following ways: economical development, educational development, agricultural development, health improvement, and better living conditions. In brief, the combination of biofuel and biomass technologies offers greater environmental benefits and the two technologies complement each other. Cogeneration of electricity is also taking place in other sugar cane producing countries, for example, Mauritius.

Wind energy

93. The energy context in Canada:

(a) Sustainable energy use in the Canadian agriculture sector is currently limited. Canadian farmers in the past have benefited from relatively inexpensive and reliable sources of non-renewable energy and, as a result, the agricultural industry is predominantly reliant upon oil and gas. Sustainable energy has been able to compete with non-renewables only in very select niche markets;

(b) The key challenge for Canadian farmers in relation to energy use is the increasing cost of non-renewable energy upon which they are predominantly dependent. Part of the solution may be the adaptation of energy conservation measures. In some instances, energy consumption can be reduced by 50-80 per cent depending on the current level of use efficiency. However, for the majority of farm activities, there are substantial economic and technological barriers to further reducing energy use. Switching to sustainable energy sources may also be part of the solution to high energy costs; however, sustainable energy currently has a low penetration in the agricultural industry and faces many challenges including early adaptation of technologies, geographical location, high capital costs, and cost competitiveness with respect to traditional energy sources;

(c) The Canadian Federation of Agriculture is a farmer-funded national umbrella organization representing provincial general farm organizations and national commodity groups. The Federation supports several policy initiatives related to climate change that are indirectly linked to farm energy use. The Federation has urged the Canadian Government to increase resources directed towards research on renewable energy technology as well as the development and strengthening of renewable energy markets; and has also requested that the Government offer industry direct support for adopting renewable energy practices and programmes that encourage all types of renewable energy.

(d) Unfortunately, in Canada, a comprehensive strategy to address high energy costs in the agricultural sector or to encourage sustainable energy use on farms has not been developed. Farmers who are interested in the adaptation of sustainable energy must look to general non-specific industry programmes to find funding, support or policy direction.

94. Wind Power Production Incentive (WPPI):

(a) Canada's wind energy resources are among the best in the world and it has installed more than 500 megawatts of wind energy capacity across the country. Wind energy can make a significant contribution to Canada's electricity needs while providing a broad range of economic and environmental benefits. Much of Canada's best wind resources are found in rural areas and wind energy can diversify rural economies, provide lease income to farmers, as well as jobs and property tax revenues for hard-pressed areas;

(b) The Government of Canada Wind Power Production Incentive (WPPI), announced in the December 2001 budget, is intended to encourage electric utilities, independent power producers and other stakeholders to gain experience in respect of this emerging and promising energy source. The Incentive will provide financial support for the installation of 1,000 megawatts of new capacity over the next five years. The incentive will cover approximately half of the current cost of the premium for wind energy in Canada compared with that of conventional sources;

(c) Over the past several years, wind developers have been prospecting windy sites across Canada and many large-scale wind farms have been proposed in Quebec, Ontario and Alberta. In many areas, rural landowners, especially farmers, have received offers to lease their land from these wind power developers. A wind farm can be integrated on farmland over thousands of acres but farmers who lease the land lose only about 1-2 per cent of their crop production and have the potential to earn from \$20,000 to \$30,000 in annual rent or royalties.

V. Key obstacles/barriers and challenges to be overcome

95. There is a lack of understanding and awareness among the general public about renewable opportunities arising from biomass, heat and biofuels. There is also bad publicity about renewable energy failures. Indeed, there is a large urban population that has little awareness of rural issues and little knowledge of non-food agricultural opportunities.

96. There is a need for public support for renewable energy production via planned usage, for example, public-procured renewable energy or planning demands for renewable energy options.

97. Another key obstacle at the governmental level involves existing regional and local governments with disparate skills, awareness and knowledge. Responsibility is often divided among multiple government departments. In the United Kingdom, for instance, four government departments cover biofuels. At the local level, it is difficult to create successful agricultural cooperatives designed to supply renewable energies.

98. Biodiesel made from plant oils is undoubtedly the most technically and commercially advanced renewable fuel today. However, this renewable source of energy — as well as most renewables — demands large initial investments both in new commercial agricultural enterprises and in biodiesel refineries.

99. The number of entrepreneurs who possess sufficient technical know-how to run a biodiesel refinery as well as the experience to develop new commercial agricultural projects is very small, and they generally cannot provide equity capital.

The challenge is to raise sufficient venture capital and to identify a sufficient number of knowledgeable entrepreneurs willing to seize the opportunity to develop the agricultural sectors and run biodiesel refineries in remote rural areas. Should this obstacle be overcome, agriculture in poor countries of the South could play a significant role in revitalizing local economies, and contribute significantly towards the replacement of dwindling crude oil supplies.

100. Economic advantages of renewable energies:

- (a) A viable alternative for farmers to producing food and to buying energy;
- (b) A positive effect on balance of payments of countries and reduced import dependency;
- (c) Strengthening of domestic rural agricultural economies by actively contributing to integrated rural development planning. In fact, renewable energies can provide an economic impetus for agricultural and rural development and help rejuvenate rural economies with a significant financial impact on farmers and agricultural businesses;
- (d) Utilization of agricultural surpluses: creation of commercial opportunities from by-products such as glycerol and oilcake;
- (e) Allowing a more efficient use of the farming potential of land and plants. Increased production of agricultural crops for non-food purposes offers the opportunity to utilize land that would have otherwise been an unexploited resource. Several animal and vegetable oils are being displaced in the food market as a result of health factors; biodiesel from these resources could offer a high-value alternative market for oilseed and tallow producers. The cropping of oilseeds takes place annually, thereby reducing long-term investment requirements. Annual crop residues (including pressed seedcake) can be burned throughout the year in local electricity generation plants, thereby smoothing out the production income cycle. Existing agricultural distribution facilities can also be utilized to convey increased oilseed production, which is not the case for any other sustainable transport fuel;
- (f) Creation of additional employment. The utilization of set-aside and underutilized land by the agricultural sector has been shown to increase employment potential by 1 person per 20 hectares dedicated to energy crops. Studies in Ireland and France indicate that the resultant regeneration of the agricultural sector can create between 11 and 15 jobs per 1,000 tons of biodiesel produced. Given that most of the production processes involved are carried out in rural areas, this provides a much-needed boost to rural agricultural economies where new job opportunities would be created.

VI. Conclusion

101. Agriculture covers approximately one third of the world's land surface and farmers are the largest group of ecosystem managers. Climate change therefore poses real challenges to farmers in terms of adapting farming methods to new weather conditions and reducing greenhouse gas emissions. The present paper demonstrates the progress that has been achieved by farmers in mitigating and adapting to climate change effects by increasing the efficiency of their farming practices, reducing emissions, and adopting carbon sequestering practices.

102. Farming is not only one of the sectors that is most affected by climate change but also a sector with a huge potential for carrying out the design of instruments and tools with which to address this problem, particularly through providing renewable sources of energies. Participation of farmers is vital through representative professional organizations which must play an essential role in decision-making, design and implementation in respect of actions related to climate change strategies.

103. However, no matter how significant their efforts, farmers and their organizations cannot bear the responsibility of adaptation and mitigation alone. The contribution of all stakeholders is of the utmost importance. Farmers are ready to propose policy orientations and provide part of the answers to different stakeholders, but they must be involved as key actors and as real protagonists.

Notes

¹ FCCP/CP/1997/7/Add.1, decision 1/CP.3, annex.

² United Nations, *Treaty Series*, vol. 1771, No. 30822.

³ Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport.

⁴ "Promoting biofuels in Europe: Securing a cleaner future for transport", brochure of the EU Directorate-General for Energy and Transport (available from http://europa.eu.int/comm/dgs/energy_transport/index_en.html).

⁵ Council directive 2003/96/EC of 27 October 2003 on restructuring the community framework for taxation of energy products and electricity.

⁶ See "The Environmental Case for Liquid Biofuels", a briefing note by Dr. Bruce Tofield and members of the CRed project at the University of East Anglia, October 2003.